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CORROSION OF AIRCRAFT PARTS AND ITS PREVENTION

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ABSTRACT: The prevention of metal corrosion is discussed. The principal corrosion causes are effects of atmosphere, chemical reactions, heated gases escaping from engines, and electro-chemical reactions in the presence of different metals and an electrolyte, dust, and the gunfire products. Corrosion prevention involves the application of protective coatings on the metal surfaces, synthetic resins 138A and A24A, primers ALG-1, ALG-5, ALG-7, enamels A-7, A-8F, A14F, KhV34, AO varnish, and the lubricant TsIATIM-201 or commercial vaseline. The parts affected were exchanged if the corrosion depth was 20-30% of the wall thickness (in the parts subjected to high stresses) and 40-50% for those under slight stress. Detection of an intercrystalline corrosion always calls for the exchange of parts. The areas affected are cleaned of the disintegration products and covered with proper primer, varnish, enamel, or lubricant. Magnesium alloys require special treatment: the oxidation film on the metal surface is restored before painting to prevent a direct contact between the metal and paint and to achieve a stronger adhesion. English Translation: 5 pages.

CORROSION OF AIRCRAFT PARTS AND ITS PREVENTION

V. N. Filimonov

The experience of the leading centers and their subdivisions proves that with intelligent operation aircraft parts can not only build up for them a regular margin of dependability but also increase it.

Aircraft parts ordinarily get out of order from corrosion breakdown or as a result of wear. An especially great amount of loss is suffered in aviation technology through corrosion, i.e., the breakdown of metals and alloys under the action of exterior media. These breakdowns appear in the form of not very deep pittings filled with easily destroyed porous material (surface corrosion) or even in the form of deep, narrow, tortuous cracks filled with the products of disintegration (intercrystalline corrosion). Sometimes different kinds of corrosion are noted on the parts at the same time.

Corrosion appearing on metal reduces the mechanical strength of the part, increases the roughness of its surface, and leads to a number of other undesirable effects. All this can prove to be the cause of technical failures in operation. Thus the increasing of the roughness of the surface of the race of a wheel bearing will cause heating of the rollers and their breakdown, and on the rod of a power cylinder of landing flaps, a sharp arbitrary banking of an airplane due to their nonsynchronous extension, etc.

One of the most widespread forms of corrosion is chemical corrosion. It arises as the result of direct chemical interaction between elements which go into the makeup of materials of which the parts of the airplane are constructed, on the one hand, and the oxygen of the air on the other. With the coming together of the oxygen with the metal on its surface it produces an oxidized film. In the case of some metals and alloys, for example, aluminum the volume of oxide formed turns out to be greater than the volume of the metal itself which has entered into chemical reaction with the oxygen. Therefore the oxide film gets so dense that it stops the access of the oxygen to the next underlying layer of metal and thereby prevents further development of corrosion. However, iron and its alloys in combination with oxygen produces a fluffy film which cannot stop the process of oxidation. As a result the part made of such materials gradually breaks down and loses its mechanical properties.

Oxidation goes on very slowly. But under certain conditions this process can be accelerated by a factor of tens and sometimes by hundreds of times. One of those conditions is high temperature with great speed of the gas flowing around the part, for example. in the gas channel of an engine and on the parts which are placed

in close proximity to the afterburner or the extension tube. The speeding up of the reaction of oxidation under the conditions of high temperature is explained by tne fact that this reaction is endocrinal, i.e., it proceeds with the absorption of heat. And in the gas channel and close to it, as is known, the heat and the oxygen are present in excess, especially in those cases where for the firing up of the basic or afterburner chambers the oxygen in the gas flow is introduced under pressure. As a result there is produced the so-called gas corrosion.

Notwithstanding the fact that the parts of the gas tract and the parts placed close to it are made of heat-resistant, strong, and anticorrosion alloys they at high temperatures nevertheless oxidize, and the higher the temperature the faster the process of oxidation goes on.

For each alloy there exists a definite limit of temperature and rate of gas flow up to which the reaction of oxidation goes on comparatively slowly. In getting above these limits the parts break down very rapidly. Many airplane specialists have observed the breakdown of the vanes of turbines in the startup of the engine in the case of failure of the fuel equipment. Most often on the damaged vanes there are traces of melting, but sometimes they partially or wholly take on the appearance of a honeycomb. This is the result of gas corrosion. Its rapid development occurs at a temperature close to the melting point of the alloy. The higher the rate of the gas flow in the intervane space the greater the difference between the temperatures of melting and the spasmodic increase in the rate of the gas corrosion will be. Therefore on the ground the probability of melting of the vanes is greater than their breakdown from gas corrosion. At time of flight on the contrary there is greater danger of the breakdown of the vanes through gas corrosion.

Another kind of corrosion quite often met with is electrochemical corrosion. It occurs and develops in the presence of two electrodes and an electrolyte. As the electrodes two metals will serve united by a joint. Such joints in the construction of an airplane are frequently the duraluminum facing and the steel longeron of the wing, the magnesium cantilever with the duraluminum wing shield and the steel bolt of its suspension, etc. If around such electrodes there comes to be an electrolyte then one of the materials serving as an anode in the galvanic pair thus formed begins to break down.

The corrosion can arise also inside of one of the materials. Here the role of the electrode is played either by the different kinds of grains of the alloy which do not have identical force of resistance to the breaking away of the ions of metal from the crystalline lattice or by grains of a uniform alloy but with different level of concentration of the inner pressure from the riveting, deformation without subsequent annealing, and from scratches on its surface.

In the case of electrochemical corrosion the material breaks down to great depth. It is known, for example, that such corrosion is suffered by the duraluminum control rods of the airplane. On their surface and deep in the material there are formed air holes which lower the strength of the rods or branching cracks, sometimes even continuous. The outer appearance of the rod in question also changes - the anticorrosion coating on it swells up. Under it there appears a gray powderlike deposit. The rod itself is sometimes deformed.

The electrochemical corrosion of magnesium alloys proceeds in an especially characteristic way. As the electrodes in it there mainly serve (cathode) and a particular solid solution (anode). The corrosion of the magnesium alloys develops very rapidly because a protecting oxide layer is not formed independently, and the force of the resistance to breakaway of the ions from the crystalline lattice is very low in the case of magnesium. As a result of the corrosion the part is covered with a white deposit containing hydroxide of magnesium and its saltlike compounds. A varnish coating swells up and is destroyed. If special measures are not taken then literally in the course of a few days the part completely gets out of order.

As the basis of the electrolyte in the formation of electrochemical corrosion moisture serves. It gets onto the airplane part at the time of rain, snowfall, sleet or fog, and also as the result of condensation in the inner open spaces of the airplane from sharp variations in temperature in returning from a high altitude, etc.

Chemically pure water will not serve as an electrolyte, but in atmospheric moisture there is always a small content of acids and salts, and especially in regions near the sea. Near industrial objects, besides, there is sulfurous gas, hydrogen sulfide, hydrogen chloride, and ammonia. All this aids atmospheric moisture in becoming a good electrolyte.

One should particularly call attention to the fact that as the electrolyte, dust and the products of firing weapons may serve, which have in their makeup salts possessing high hydroscopicity. When dust particles get onto the part, and especially when the products of burnt powder settle on it they create corrosion centers producing local corrosion of the metal. The products of corrosion also as a rule are hydroscopic. Therefore when they are formed in one place the corrosion rapidly takes over consider area of the part.

Thus, corrosion, chemical or electrochemical in damaging parts breaks down the conditions of normal operation in aviation technology.

The means used in industry for anticorrosion protection with the correct procedure in applying them fully assure protection of the different parts against corrosion. However, infractions in the operation of an airplane on the part of engineering personnel can lead to damaging of parts by corrosion. Therefore it behooves the aviation specialists in the interest of preserving the technology not only punctually to carry out the requirements of the instructions on the operation in which there are explained all the necessary measures for preventing corrosion but also to promote a number of supplementary measures in the organization of the proper care of the airplane. For example, in avoiding the breakdown of the vanes of turbines from gas corrosion in accordance with the instructions it is not permitted to allow the engines to operate at too high a temperature of the input gases. It is also forbidden to allow a flareup of temperature of the output gases above determined values and in course of a determined time, i.e., actually to limit the figure for the gradient of temperature of the gases over the time. And this is not arbitrary; the point is that it is known that with different regulations of the fuel of the apparatus this gradient can be changed from 10 to 30° in a second in starting the engine up to 25-50° in trying out the pickup. Such a sharp change in the temperature of the gases brings about a chipping of the oxide layer from the surface of the vanes of the turbine and a speeding up of the process of gas corrosion of their forward and rear edges. In order to exclude the possibility of burning the valves of a jet nozzle the instructions point out the necessity of maintaining definite clearances between the parts of a jet nozzle and the inner contours of the fuselage of the airplane.

The most effective and acceptable means of preventing corrosion of all kinds under the conditions of operation in aviation technology proves to be the application of a varnish covering on the surface of a repaired or a newly made part. By a combination of varnish coverings one is able to obtain a good coupling of them with the material of the part and at the same time the formation of a protective film of high density. Let us present an example of one of such combinations. Onto a part from which previously the grease has been removed there are applied one or two layers of a primer on an oily base. After the complete drying of the primer on its surface there is applied a layer of enamel or lacquer. Both the primer and the lacquer or enamel contain in their composition also pigments which in the best way protect the covered part of corrosion. Here one should note that varnish coverings of one and same brand cannot be used for parts of different metals. Thus for the protection of steel from corrosion it is best of all to use the glyptal primer 138A (of red color), the pigments of which are iron minimum and lead chrome. The first with respect to steel is neutral; the second in the presence of an electrolyte becomes an anode and breaking down itself preserves the steel from corrosion. Such qualities are also possessed by the enamel A-14F.

For the purpose of protecting the aluminum alloys there is used the primers ALG-1 (yellow color) and ALG-5 (sulfur-yellow color). In the first as a pigment there is used zinc chrome; in the second zinc chrome and white. As the second coating there are used enamels A-7 and A-8F or the lacquer AO, which proves to be very stable against gasoline, kerosene and lubricating oils.

For preventing the formation of corrosion more significance is had by the presentation over the course of considerable time of a varnish covering in the

undamaged state. For this purpose it is necessary carefully to cover the outfit and the whole glider but when working on an airplane to use the protective scaffolding and efficient tools. One cannot allow that on the varnished parts there be spilled fuel, oil, or other special liquids, and when the coating is broken through it is necessary to take measures in time to restore it.

As is known, a considerable number of airplane parts do not have varnished coating. For the prevention of the corrosion of these parts one uses different kinds of grease. Thus for the protection of steel parts one uses TsIATIM-201 [the letters stand for Central Scientific Research Institute of Aviation Fuel and Oils] and parts of aluminum alloys – TsIATIM-201 and industrial vaseline. The truth is all these lubricants do not fully satisfy the requirements since they possess hydroscopicity, i.e., capacity for absorbing and passing through to the surface of the protected material moisture, which in accumulating under the layer of grease brings about corrosion of the part. Besides this, the grease oxidizes, which results in lowering its protective properties. However, in spite of the indicated shortcomings the grease with the proper use proves to be a dependable protecting medium. For this it is necessary to see that the grease is spread over the part in an equal and thin layer following the configuration of the part covering the whole surface to be protected, and what is most important it should be renewed periodically. The periods for the change of the grease are determined by the accrued operating time, the temperature, and the dirt in the surrounding air, as well as the continuance of the preservation, etc. To this one can add that the nonfulfillment of these requirements this to be true. On one of the airplanes in carrying out the regulation operations there was made a change of the grease in a supporting bearing of the beam of the stabilizer. But since at the moment of its stuffing the stabilizer was not turned there was greased only a part of the bearing located in close proximity to the lubricant. Naturally some time later the bearing broke down. In dismanteling on the races there were discovered corrosion pits.

In practice it is necessary not only to protect the parts from corrosion but also to remove its traces. Here two points are very important – to know how to determine the degree of damage of the material and to present the further spreading of the corrosion. The depth of the damage to the material is determined after full removal of the products of the corrosion and of the pits or cracks formed as the result of its development. For the power elements of the aircraft – the control rods, the tubular channels, sheathing. The depth of the damage should be not more than 20 to 30% of the thickness of the wall. The parts with greater depth of the damage should be changed. For the parts that do not carry a great load one can tolerate damage to 40 or 50%. The examination of the protected place should be done through a magnifying glass with a power of 5 to 10. This enables one to discover cracks in the metal which are formed as a result of its weakening through corrosion and fine porosity which shows up the development of intercrystal corrosion. In the latter case the part without exception should be changed.

After cleaning the damaged spot and 10 to 15 mm of the protecting covering surrounding it there is applied a new coating as determined for each metal. Thus for steel and alloys on an aluminum base this will be a primer, lacquers, enamels, or grease.

For parts of magnesium alloys the process of restoring the protective covering is somewhat more complicated. Before applying it is indispensable the oxidized film which serves for exluding the direct contact with the metal of the varnish coating and improving the union between the two. As a restorer of the oxidized film there is used an aqueous solution of "khrompin" and selenious acid in the proportions 1000:10:20.

The part from which the products of corrosion has been fully removed is rubbed with a cotton pad soaked in this solution and then dried in the air for about ten minutes. After this there is applied the primer ALG-7 which has good protective properties. In the second layer of the prime there is added 10% of aluminum powder to protect the first layer from the action of the Sun's rays. The primer is covered with a coating of glyptal enamel A24A of water-resistant perchlorovinyl enamel KhV34.

In the present article we have considered methods of preventing corrosion on parts and protecting parts from its action which are available to every airplane specialist under any conditions of the operation of airplanes. Experience has shown that where the engineering technical staff has exercised careful control over the state of the protective coverings of the parts of the airplane and the engine there is a very considerable lengthening of the period of their service.